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ISA

Novi Sad, Serbia

June 20-23, 2022

Proceedings of the

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June 20-23, 2022

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Proceedings of the 20th International Sunflower Conference
Novi sad, Serbia, June 20-23, 2022

Editors: Sreten Terzić, Dragana Miladinović

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The proceedings or the 20th International Sunflower Conference contain 153 contributions from scientists of 30 countries. They include plenary lectures, oral talks and regular communications presented with posters, among which, selected contributions were emphasized with short oral talks. The manuscripts are classified by research areas in ten separate sections. They offer a thorough review of the current state of the art of sunflower research and production around the world. The Organizing Committee is grateful to Tanja Vunjak and Aleksandar Vojisavljević for their excellent editorial assistance in the preparation of these Proceedings.

ISC2022 Organizing committee

Conference program

Sunday, 19 June

16.00-21.00	Registration
19.00-21.00	Welcome Reception

Monday, 20 June

8.00-17.00	Registration	
9.00-9.30	Opening Ceremony	
9.30- 10.15	**Invited talk** Section 1: Dr. Felicity Vear (France)	
10.15-11.00	Coffee break	
11.00-12.00	**Section 1:** *Breeding – New/old breeding goals and challenges*	**Section 2:** *Oils and proteins - Innovations for increased quality and feedstock supply*
	Oral and short oral presentations	**Oral and short oral presentations**
12.00-13.30	Lunch	
13.30-14.30	**Invited talks** Section 3: Dr. C.C. Jan (China) Section 4: Dr. Sreten Terzić (IFVCNS, Serbia)	
14.30-15.00	Coffee break	
15.00-16.00	**Section 3:** *Confectionery sunflower – Emerging crop*	**Section 4:** *Genetic resources – Investment for the future*
	Oral and short oral presentations	**Oral and short oral presentations**
16.00-17.00	**Poster session** – Sections 1, 2, 3, 4	
18.00-21.00	Novi Sad and Petrovaradin fortress tour	

Tuesday, 21 June

8.30-17.00	Registration	
9.30-10.30	**Invited talks** Section 5: Dr. Leire Molinero Ruiz (CISC, Spain) Section 6: Dr. Philippe Debaeke (INRAE, France)	
10.30-11.00	Coffee break	
11.00-12.00	**Section 5:** *Biotic stress resistance – New and emerging pests and diseases*	**Section 6:** *Crop production and modeling – Yield stability in changing environment*
	Oral and short oral presentations	**Oral and short oral presentations**
12.00-13.30	Lunch	
13.30-14.30	**Invited talks** Section 7: Dr. Nicolas Langlade (INRAE, France) Section 8: Etienne Pilorgé (Terres Inovia, France)	
14.30-15.00	Coffee break	
15.00-16.00	**Section 7:** *Abiotic stress resistance – Challenges of changing environment*	**Section 8:** *Economy and market – Trends and prospects*
	Oral and short oral presentations	**Oral and short oral presentations**
16.00-17.00	**Poster session** – Sections 5, 6, 7, 8	

Wednesday, 22 June

8.30-17.00	Registration	
9.30-10.30	**Invited talks** Section 9: Dr. Stéphane Muños (INRAE, France) Section 10: Dr. Nicole Creux (FABI, South Africa)	
10.30-11.00	Coffee break	
11.00-12.00	**Section 9:** Broomrape – *Constant challenge*	**Section 10:** *Bees and seeds – Exploring new venues for increased yield and seed production*
	Oral and short oral presentations	**Oral and short oral presentations**
12.00-13.30	Lunch	
13.30-14.30	**Panel:** *Sunflower in a changing environment – Trends and prospects*	
14.30-15.00	Coffee break	
14.30-15.30	**Poster session** – Sections 9, 10	
15.00-16.30	ISA Assembly	
16.30-17.00	Closing ceremony	
20.00-24.00	Gala Dinner Pustavoit Award Presentation Ceremony IFVCNS Best Poster Award Presentation	

Thursday, 23 June

9.00-15.00	Field day

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CONFECTIONERY SUNFLOWER IN SERBIA

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Abstract

Serbia is one of the leading countries in the Balkans both in production and breeding of high-protein confectionery sunflower, although the area under this crop in Serbia is rather small. The use of NS confectionery sunflower hybrids in production, the processing industry and smaller factories has increased. Large seed fractions are purchased, roasted and packed individually, while smaller seed fractions are used in the production of cold-pressed sunflower seed oil and oil cake. It is expected that NS confectionery hybrids will continue to increase in production and gradually replace other varieties. A confectionery sunflower breeding program has been established at IFVCNS in mid-90s with the aim of developing modern confectionery open-pollinated hybrids. The increased use of plant proteins in the food industry imposed new goals on breeding programs. Hence, the confectionary sunflower breeding program places special emphasis on creating hybrids that fit their intended market segment. This can relate to purpose and intended use–whether food or bird feed– or different production conditions–classical or organic production. The hybrids created in NS breeding programs enable the use of intensive cultivation practices and mechanized harvesting and provide a stable seed and protein yield. The continued creation of new confectionery hybrids with increased genetic potential for seed and protein yield, protein content, resistance to pathogens and herbicides will allow more efficient use of genetic resources of the confectionary population taking part in the breeding programs. In Serbia, confectionery sunflower hybrids are produced on a smaller scale both in conventional and organic production systems, with constant increase of the area under organic production. Characterized by decreased seed oil content and increased seed protein content, the NS confectionery hybrids respond to a great extent to production and market demands of EU, Russia and Balkan countries. They maintain their presence in the Iranian, Albanian, and Chinese markets.

Key words: confectionery sunflower, breeding, market, Serbia

Introduction

Serbia is one of the largest European sunflower producers (Miklič et al., 2018) and one of the leading countries in the Balkan Region both in production and the breeding of confectionery sunflower. High-protein or confectionery sunflower has a separate market from the oil type sunflower, as it is used in the food industry and roasted or dehulled and used as a whole seed or component of snacks and baker's wares, or as bird and pet feed (Hladni, 2016; Hladni and Miladinović, 2019). Apart from proteins, confectionery high protein sunflower hybrids also

contain significant oil quantities that used to obtain cold press oils and oil cake as a by-product (Hladni et al., 2021; Lužaić et al., 2021a). The market for confectionery seeds is growing, with most customers preferring tasty, high-quality, and longer confectionery type seeds, but preferences differ according to the region or country (Hladni and Miladinović 2019). Large open-pollinated confectionery varieties, with large black seeds, have been grown in the past, but in the last few years they start to be replaced by NS confectionery hybrids, leading to increase of their use in the production, processing industry and smaller processing factories. Large seed fractions are roasted and packed individually, while smaller seed fractions are used in the production of cold-pressed sunflower seed oil (Hladni and Miladinović 2019).

In this paper we give an overview on the status and future perspective of genetic resources, breeding and use of confectionery sunflower in Serbia.

Genetic resources – Status and tools diversity analysis

Knowledge of genetic diversity of confectionary sunflower can have a large impact on its use in breeding programs, so characterization of the existing sunflower collections is essential for breeders (Tan et al., 2016) However, levels and distribution of genetic variation within the confectionery sunflower gene pool are still not adequately explored. Adequate selection of traits used in confectionery germplasm evaluation can improve the efficiency of breeding programs Appropriate descriptor evaluation is important both during early inbred line development and during the evaluation of combining abilities. An efficient method for a comprehensive overview of genotype diversity and group homogeneity is the HOMALS analysis of morphological descriptors (Hladni et al., 2017; Terzić et al., 2019). Hladni et al. (2017a) used the Shannon diversity index (H) to evaluate the variability of 68 confectionary sunflower genotypes based on 32 morphological descriptors. The high diversity index value (0.7) suggests that the evaluated material is a representative confectionary sunflower germplasm collection.

HOMALS analysis indicates the importance of descriptor selection for germplasm evaluation. Based on this, the most informative trait was coloration of stigma (DFIA), seed color of stripes (SCS), and seed main color (SMC). These had the highest variability, and also the highest discriminative power among genotypes. Isolated genotypes that may not stand out based on their yield or seed-specific traits can be useful sources of traits for breeding. Thus, morphological characterization can be used to improve the description and classification of confectionary sunflower germplasm when evaluating diversity (Hladni et al., 2017a). Considering, therefore, the diversity of the studied material, it is safe to assume that it has a high potential for long-term exploitation in the breeding of adaptability in confectionery sunflower for both abiotic stress tolerance, and for extreme environmental tolerance, the latter being particularly important as such conditions are more common in the era of climate change.

Breeding – Programs and introduction of hybrids

Breeding program for confectionery sunflower in Serbia has been established at Centre for Agricultural and Technological Research in Zaječar and in IFVCNS during the 1980s. It is directed towards the increase of the genetic potential for yield, stability of yield, health, and the quality of nutrition along with the increase of the production economy (Hladni et al., 2011). Specific breeding goals for confectionery sunflower are high mass per 1000 seeds, low content of hull, high content of proteins, and low oil content (Dozet and Jovanović, 1997; Jovanović, 2001; Dijanović et al., 2003). Since the results of a number of researchers show that the protein content of sunflower seeds varies in a wide range from 13% to 28% (Stanojević et al., 1992; Jovanović and Stanojević, 1996), higher and more stable protein yield is an ultimate objective of confectionary sunflower breeders. Hence, in the breeding process it is important to identify traits which could be used as selection criteria for

increased protein content in seeds and develop efficient methods and tools for predicting oil and protein yields depending on parameters of cultivation, such as artificial neural networks (ANNs) (Hladni et al., 2015; Hladni et al., 2017b; Hladni et al., 2021; Lužajić et al., 2021b).

Many years of breeding work on confectionery sunflower in IFVCNS led to creation of new NS confectionery hybrids, which are registered in Serbia, EU, and Russia. NS confectionery hybrids respond to a great extent to production and market demands of EU, Russia and Balkan countries. They also maintain their presence in the Iranian, Albanian and Chinese markets (Hladni and Miladinović, 2019). The advantages of hybrids in comparison to varieties are crop uniformity, suitability for mechanized harvesting as well as seed quality. Confectionery hybrids have significantly higher seed yield than open-pollinated varieties, as well as resistance to biotic and abiotic stresses (Hladni et al., 2018). Their yield is on the same level as the yield of oil hybrids, over 4 t/ha, selected seed 3.5 t/ha, and the price is significantly higher per kg, sometimes even double, depending on the seed fraction. Many small farmers in Serbia are producing NS confectionery hybrids such as NS Gricko, NS Leviathan, NS Slatki, NS Garavi and NS Goliat. NS confectionery hybrids can be used to obtain edible unrefined cold pressed oil (Romanić et al., 2020; Lužanić et al., 2019; Lužanić et al., 2021a). Hence, it is expected that confectionery hybrids will continue to increase their share in production and completely replace the varieties (Hladni, 2016).

Future directions in sunflower breeding in Serbia

In order to achieve high and stable confectionery hybrid yield it is important to create a model of a sunflower plant which would enable an increase of the number of plants per hectare in the conditions of intensive cultivation practices and mechanized harvesting (Hladni and Miladinović, 2019). It is necessary to pay more attention to the architecture of plant organs, like petiole angle, petiole length, plant height and number of leaves per plant, which directly influence the change of the photosynthetic apparatus. Breeding programs should find solutions for empty and under-developed seeds, especially in the center of the flower head, as well as for a high husk percentage in kernels, and decreased dehullability (Hladni, 2016). One of the goals in confectionery sunflower breeding, besides high protein content, is creation of hybrids with high oleic acid and tocopherol content. Organic fertilizers could be used for improvement of fatty acid composition and tocopherol content in organic cultivation of sunflower (Babec et al., 2019). In the future, confectionery sunflower breeding will be focused on an integrated multidisciplinary approach based on genetics and genomics, physiology, and modelling, along with the application of modern breeding tools, should be used for designing novel sunflower varieties, more resilient to abiotic stresses and extreme environmental conditions, particularly drought tolerance (Hladni et al., 2022). The cooperation and exchange of breeding material from different breeding centers, as well as creation of joint hybrids, has gained importance in recent years as a tool for creation of new, more resilient and productive confectionery hybrids, ready to face both challenges from the market in Serbia and others countries (Hladni et al., 2018). Goals of particular importance in breeding are the creation of hybrids resistant or tolerant to diseases and broomrape while also incorporating herbicide-tolerant traits, especially to Imidazolinones (IMI) and Sulfonyl Urea (SU). Finally, the combination of confectionery sunflower and legumes, while rarely used in practice, promises to improve not only sustainability of the production system but also yield (Babec et al., 2021).

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